

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 19

PEORIA COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE
AND F. W. GARRETT
PREPARED FOR PUBLICATION BY L. H. SMITH



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IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

PEORIA COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE, AND F. W. GARRETT
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FORMATION

Peoria county is located in the northwest-central part of Illinois just west of the Illinois river. It lies in the upper Illinoian and early Wisconsin glaciations. In general, it varies in topography from flat to slightly rolling in the northern and northwestern parts, to hilly along the Illinois river and the Kickapoo creek.

The variations in topography are due to three causes—glaciers, streams, and wind. During the Glacial period, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an extent that the mass pushed outward from these centers, especially southward, until a point was reached where it melted as rapidly as it advanced. In moving across the country, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, ordinary boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks or against each other until largely ground into powder. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier would accumulate in a broad undulating ridge or moraine. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the area previously covered. During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. Between these advances the glacial material deposited was transformed into soil in part and then buried by other advances.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The material carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of material deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers then was to change the surface from hilly to gently undulating. Streams subsequently did a large amount of work, and as a result more

than a quarter of Peoria county has been cut up into hills and valleys. This has reduced the value of the land and rendered it unfit for ordinary agriculture, altho much of it is well adapted to pasturing.

A deposit of wind-blown dust, or loess, was made during the Glacial period, to a depth of 5 to 15 feet over the upland. Since this deposit was relatively uniform, it modified the topography but slightly. On the terrace in the north-eastern part of the county, the wind has formed sand dunes from the sand deposited by the Illinois river, emphasizing the irregularities that originally existed.

THE GLACIATIONS OF PEORIA COUNTY

Peoria county was first covered by the Illinoisan glacier, which left a deposit of boulder clay, resulting in a partial leveling of the region. After the recession of this glacier, a long period elapsed, during which a soil was formed by the incorporation of organic matter in the glacial material deposited. This soil is known as the Sangamon soil. Then another advance occurred, known as the Iowan glacier, that did not reach Peoria county, but during its melting the region now included in Illinois was probably covered with a deposit of wind-blown dust or loess from 10 to 15 feet thick, burying the Sangamon soil. A new soil, called the Peorian, was formed from the surface of the loess, and after another long period had elapsed, a third ice advance occurred, known as the early Wisconsin glacier. This ice sheet covered the northeastern third of the county, burying the Illinoisan drift and the Sangamon soil still deeper, and covering the Iowan loess and the Peorian soil.

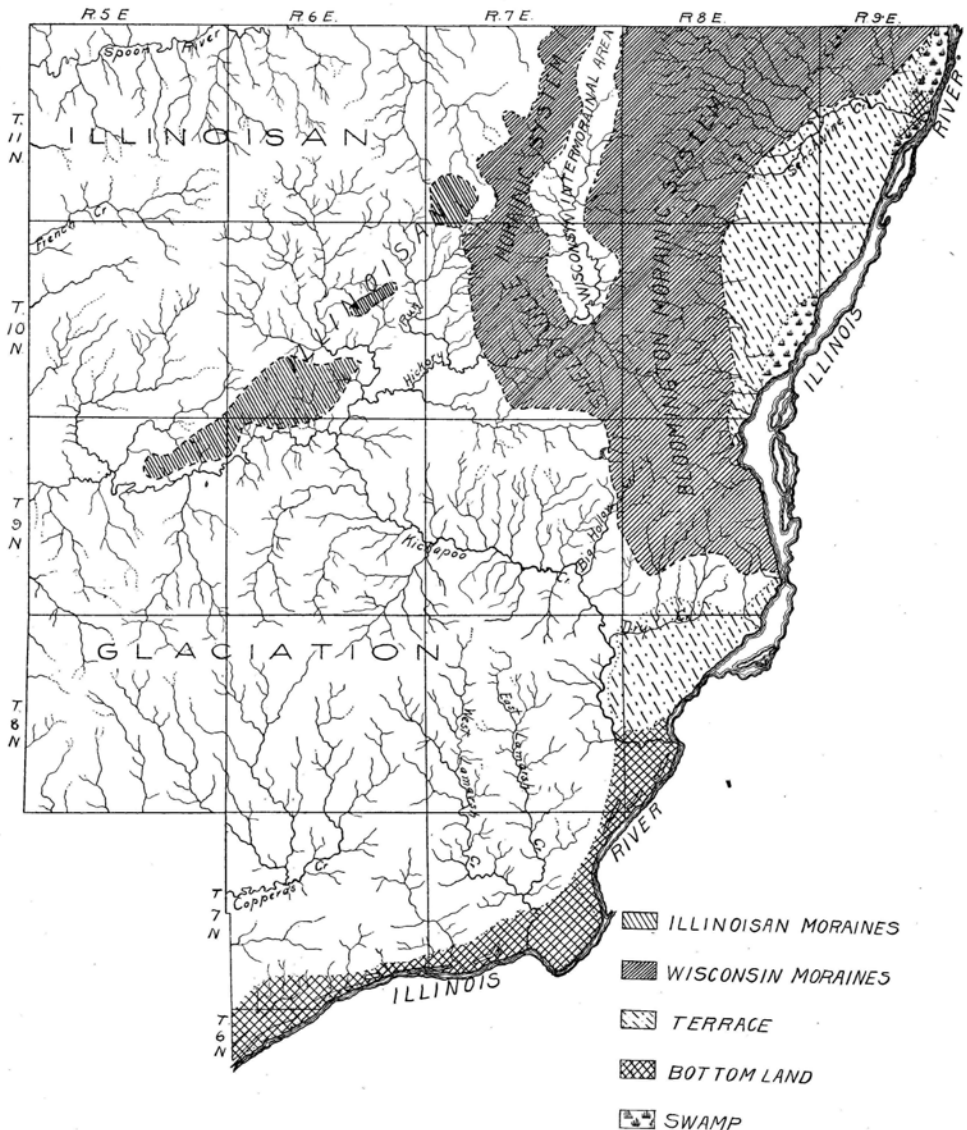
This early Wisconsin glacier built up two extensive moraines, the west one, known as the Shelbyville, and the eastern, the Bloomington. These coalesce in Tazewell county before they cross the Illinois river; then divide south of Dunlap into two distinct ridges, and unite again in the extreme northern part of Peoria county. The deposit of glacial material in the vicinity of these moraines varies from 150 to 200 feet in thickness. In some parts, particularly along the lower Kickapoo creek, this is made up largely of stratified gravel. In places sufficient calcium carbonate has been deposited in this gravel to cement it together, thus producing conglomerate. (See state soil map in Bulletin 193.) A smaller morainal ridge built up by the Illinoisan glacier extends southwest near the center of the western part of the county. The moraines of the early Wisconsin glaciation are about 100 feet higher than the general level of the Illinois glaciation.

The early Wisconsin drift is covered with a deposit of loess from 3 to 6 feet deep, except on the more rolling parts, where it has been largely removed by erosion.

PHYSIOGRAPHY AND DRAINAGE

The altitude of Peoria county varies from 835 feet, the highest point, to below 436 feet, the low-water mark in the Illinois river at Peoria.

The altitudes of some places in the county are as follows: Alta, 751 feet; Brimfield, 729; Chillicothe, 490; Cramer, 765; Dunlap, 724; Edelstein, 781; Eden, 727; Edwards, 519; Elmwood, 626; Glasford, 615; Hanna City, 732; Keller, 801; Kramm, 540; Laura, 732; Mapleton, 467; Maxwell, 594; Monica, 772; Oak Hill, 557; Peoria (low water), 436; Peoria Heights, 768; Pottstown, 486; Princeville, 745; Rome, 485; Trivoli, 748.



MAP SHOWING THE DRAINAGE BASINS OF PEORIA COUNTY WITH MORAINAL, TERRACE, BOTTOM-LAND AND SWAMP AREAS

The entire county lies in the basin of the Illinois river, but the northwest part is drained by Spoon river, while Kickapoo creek drains the larger part of the remainder of the county. The large prairie region lies in the northern and western parts of the county. The northeastern part of the county includes a sand and gravel terrace with irregular areas to the south along the river. The largest of these outside of the Chillicothe area, is at Peoria. The terrace at Peoria occupies at least two distinct levels, the one about a hundred feet above the other. The total prairie area comprizes about 40 percent of the county.

The county contains a large amount of hilly land, totaling about 28 percent of the area. The streams flow in deep valleys that are from 100

to 300 feet below the upland. The principal area of this eroded land is along Kickapoo creek in the central part, while Copperas and Lamarsh creeks with their tributaries are responsible for a large amount of hilly land in the south part. Spoon river has produced an area of several square miles of rough land in the northwest part of the county. Another such area from one to four miles wide has been formed along the Illinois river bluff north of Kickapoo creek.

SOIL MATERIALS AND SOIL TYPES

While the two glaciers which reached Peoria county left extensive deposits of boulder clay or glacial drift, the soils as a rule are not formed from this material. The boulder clay has been covered by a deposit of loess or wind-blown material and this constitutes the soil-forming material. In some of the more rolling areas the loess has been removed and the glacial material is now exposed and constitutes the different soil strata. In some cases, however, sufficient loess still remains to form the surface and subsurface and perhaps part or all of the subsoil.

The soils of the county are divided into the following groups:

(a) *Upland Prairie Soils*.—These are rich in organic matter. The partially decayed roots of the wild prairie grasses which once flourished on these areas have been the principal source of the organic matter. The flat prairie land contains the higher amount of this constituent because the grasses and roots grew more luxuriantly there, and the higher moisture content preserved them from complete decay.

(b) *Upland Timber Soils*.—These are found in the zones along stream courses, upon which forests have grown for a long period. They contain much less organic matter than the prairie soils, because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two classes—the undulating and the hilly areas.

(c) *Terrace Soils*.—These were formed at the time of the melting of the glacier by deposits of gravel and sand from flooded streams overloaded with sediment. Finer deposits which were later made upon the coarse gravelly material now constitute the soil.

(d) *Old Swamp and Bottom Lands*.—These include the flood plains occurring along streams in the older glaciation, the Illinoisan, and some small peaty swamp areas.

(e) *Late Swamp and Bottom Lands*.—These include the newer formations occurring along the streams of the early Wisconsin glaciation and along the Illinois river. The sand and gravel terrace was formed during the recession of the Wisconsin glacier, but the only loessial material found there is what has been carried down by streams. This, of course, has been reworked from the ordinary upland loess, and would therefore be classed as an alluvial deposit.

In Table 1 is given the area of each type of soil in Peoria county, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil, even when the type covers but a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables the reader is referred to the first part of the Appendix of this report.

TABLE 1.—SOIL TYPES OF PEORIA COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
(a) Upland Prairie Soils (200, 500, 900, 1100)				
226 526 926 1126	Brown silt loam.....	208.75	133,600	33.64
520 1120 1520	Black clay loam.....	1.56	998	.25
528 928	Brown-gray silt loam on tight clay.....	1.47	941	.24
		211.78	135,539	34.13
(b) Upland Timber Soils (200, 500, 900, 1100)				
234 534 934 1134	Yellow-gray silt loam.....	128.13	82,003	20.65
235 535 935 1135	Yellow silt loam.....	172.59	110,458	27.81
		300.72	192,461	48.46
(c) Terrace Soils (1500)				
1560	Brown sandy loam.....	16.66	10,663	2.68
1526	Brown silt loam.....	6.57	4,205	1.06
1571	Brown fine sandy loam.....	4.49	2,874	.72
1581	Dune sand.....	2.81	1,798	.45
1526.4	Brown silt loam on gravel.....	4.78	3,059	.77
1536	Yellow-gray silt loam over gravel.....	3.34	2,138	.54
1564	Yellow-gray sandy loam.....	1.91	1,222	.31
1564.4	Yellow-gray sandy loam on gravel.....	.16	102	.03
1560.4	Brown sandy loam on gravel.....	.41	262	.07
1528	Brown-gray silt loam on tight clay.....	.18	115	.03
		41.31	26,438	6.66
(d) Old Swamp and Bottom-Land Soils (1300)				
1326	Deep brown silt loam.....	8.41	5,383	1.35
1354	Mixed loam.....	38.40	24,576	6.19
1301	Deep peat.....	.06	38	.01
		46.87	29,997	7.55
(e) Late Swamp and Bottom-Land Soils (1400)				
1426	Deep brown silt loam.....	9.55	6,112	1.54
1454	Mixed loam.....	1.25	800	.20
1415	Drab clay.....	4.64	2,970	.75
		15.44	9,882	2.49
(f) Miscellaneous				
	Water.....	.46	294	.07
	Swamp.....	3.76	2,407	.60
	Gravel pits.....	.26	166	.04
		4.48	2,867	.71
	Total area.....	620.60	397,184	100.00

INVOICE OF PLANT FOOD IN PEORIA COUNTY SOILS

SOIL ANALYSIS

The composition reported for a given soil type is, for the more extensive types, the average of several analyses which, like most things in nature, show more or less variation. For most practical purposes, however, the average composition may be considered sufficient to characterize in a general way the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amounts of organic carbon (the best measure of the organic matter) and the total amounts of the six important elements of plant food—nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium—contained in 2 million pounds of the surface soil of each type in Peoria county. In addition, the table shows the limestone equivalent of the carbonates, in case any are present, or the soil acidity as measured by the amount of limestone required to neutralize it.

The variation among the different types of soil in Peoria county with respect to their content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, eleven times as much nitrogen as the yellow silt loam, and about four times as much nitrogen but only about one-twentieth as much potassium as the brown silt loam. The total supply of phosphorus in the surface stratum varies from 680 pounds per acre in the dune sand to 2,190 pounds in the deep peat. The magnesium varies from about 4,700 to as much as 30,000 pounds; and the calcium content ranges from less than 6,000 pounds to more than 200,000 pounds per acre. Some types contain an abundance of limestone while others are slightly acid in the surface, more strongly acid in the subsurface, and sometimes devoid of limestone even in the subsoil. Only a very small proportion of the soils of the county contain any limestone in the surface or subsurface to a depth of 20 inches.

Some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found by easy computation that the most common upland soil of Peoria county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus, the condition differs only in degree, this most important upland soil of the county containing no more of that element than would be required for fourteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for almost 26 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

TABLE 2.—PLANT FOOD IN THE SOILS OF PEORIA COUNTY, ILLINOIS: SURFACE SOIL

Average pounds per acre in 2 million pounds of surface soil (about 0-6 $\frac{2}{3}$ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone equivalent of carbonates present ¹	Soil acidity present ¹
(a) Upland Prairie Soils (200, 500, 900, 1100)										
-26	Brown silt loam.....	57,730	4,590	1,080	760	32,870	9,150	10,860		
-20	Black clay loam.....	75,460	7,190	1,690	1,120	32,530	12,760	20,870		
-28	Brown-gray silt loam on tight clay	43,680	4,000	1,200	720	32,980	7,100	7,820		
(b) Upland Timber Soils (200, 500, 900, 1100)										
-34	Yellow-gray silt loam.....	25,310	2,440	900	600	34,320	6,380	12,910		
-35	Yellow silt loam.....	19,050	1,690	910	330	37,990	9,240	7,850		Sometimes
(c) Terrace Soils (1500)										
-60	Brown sandy loam.....	23,910	1,430	770	560	23,850	5,090	5,800	28,230	
-26	Brown silt loam.....	41,220	3,480	1,340	680	41,380	8,920	8,840		
-71	Brown fine sandy loam.....	34,350	3,260	1,440	670	42,890	14,300	20,410		
-81	Dune sand.....	10,220	860	680	260	16,820	5,480	7,560		
-26.4	Brown silt loam on gravel.....	34,740	2,820	1,040	680	28,240	9,020	9,360		
-36	Yellow-gray silt loam over gravel	24,880	2,920	1,180	560	39,760	4,700	7,300		
-64	Yellow-gray sandy loam.....	23,100	2,180	1,220	420	32,960	5,360	6,960		
-64.4	Yellow-gray sandy loam on gravel	29,070	2,650	1,070	380	40,130	7,980	8,430		
-60.4	Brown sandy loam on gravel.....	32,440	2,740	1,080	660	27,140	6,740	7,220		
-28	Brown-gray silt loam on tight clay	43,080	4,020	1,620	720	42,340	9,500	7,240		
(d) Old Swamp and Bottom-Land Soils (1300)										
-26	Deep brown silt loam.....	41,920	3,400	1,380	560	34,840	13,980	20,480	24,800	
-54	Mixed loam.....	27,360	2,360	1,240	480	39,620	16,840	23,700	53,120	
-01	Deep peat ²	207,920	19,390	2,190	2,900	1,530	6,700	201,810	434,740	
(e) Late Swamp and Bottom-Land Soils (1400)										
-26	Deep brown silt loam.....	50,200	4,320	1,570	840	43,990	23,070	31,060	Sometimes 168,710	
-54	Mixed loam.....	43,610	3,750	1,310	710	38,450	30,000	51,750		
-15	Drab clay.....	48,340	4,520	1,540	860	44,920	20,640	15,600		

¹Where neither carbonates nor acidity is reported it is understood that the soil is either neutral or so nearly neutral as to be within the limits of the experimental error of determination.

²Amounts reported are for 1 million pounds of deep peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF PEORIA COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6½-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone equivalent of carbonates present ¹	Soil acidity present ¹
(a) Upland Prairie Soils (200, 500, 900, 1100)										
-26	Brown silt loam.....	79,380	6,510	1,790	1,160	66,030	23,170	22,160		
-20	Black clay loam.....	118,680	9,220	3,020	1,960	65,460	30,040	42,220		
-28	Brown-gray silt loam on tight clay	41,080	4,320	2,000	800	67,360	17,280	14,160		320
(b) Upland Timber Soils (200, 500, 900, 1100)										
-34	Yellow-gray silt loam.....	18,210	2,280	1,520	560	71,380	22,980	16,350		Sometimes
-35	Yellow silt loam.....	16,020	1,870	2,090	420	77,760	30,860	24,590	Sometimes	Sometimes
(c) Terrace Soils (1500)										
-60	Brown sandy loam.....	44,760	3,880	1,580	920	49,300	11,880	11,620		
-26	Brown silt loam.....	56,360	5,240	2,200	1,520	86,600	21,560	18,200		
-71	Brown fine sandy loam.....	53,080	4,760	2,520	1,300	81,960	35,720	70,660		
-81	Dune sand.....	20,240	1,360	1,360	720	35,960	12,240	16,000		
-26.4	Brown silt loam on gravel.....	63,640	5,760	2,080	1,520	58,360	22,240	18,680		
-36	Yellow-gray silt loam over gravel	19,000	2,560	1,920	520	81,880	12,680	12,600		
-64	Yellow-gray sandy loam.....	20,240	2,360	2,360	560	72,040	14,880	13,360		
-64.4	Yellow-gray sandy loam on gravel	25,560	3,000	1,620	700	89,600	23,500	15,800		
-60.4	Brown sandy loam on gravel.....	57,520	4,920	2,000	1,040	56,600	16,400	12,680		
-28	Brown-gray silt loam on tight clay	32,440	3,160	1,840	440	90,400	26,280	14,040		280
(d) Old Swamp and Bottom-Land Soils (1300)										
-26	Deep brown silt loam.....	96,240	8,000	3,360	1,160	71,920	31,080	44,320	45,320	
-54	Mixed loam.....	56,520	4,800	2,520	880	77,360	30,120	42,080	75,680	
-01	Deep peat ²	552,460	43,420	3,820	7,640	3,920	12,240	342,260	682,760	
(e) Late Swamp and Bottom-Land Soils (1400)										
-26	Deep brown silt loam.....	69,780	6,340	2,600	1,400	84,960	46,320	64,220	Sometimes	
-54	Mixed loam.....	50,500	4,600	2,400	1,040	73,100	69,240	117,920	424,200	
-15	Drab clay.....	49,000	5,640	2,240	1,040	49,240	42,440	31,400		

¹Where neither carbonates nor acidity is reported it is understood that the soil is either neutral or so nearly neutral as to be within the limits of the experimental error of determination.

²Amounts reported are for 2 million pounds of deep peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF PEORIA COUNTY, ILLINOIS: SUBSOIL

Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone equivalent of carbonates present ¹	Soil acidity present ¹
(a) Upland Prairie Soils (200, 500, 900, 1100)										
-26	Brown silt loam.....	38,190	4,250	2,210	1,020	101,580	47,240	34,460		
-20	Black clay loam.....	49,350	4,110	3,450	1,380	103,860	47,850	52,320		
-28	Brown-gray silt loam on tight clay	30,120	3,720	3,360	540	103,200	46,800	32,220		480
(b) Upland Timber Soils (200, 500, 900, 1100)										
-34	Yellow-gray silt loam.....	19,840	2,710	2,940	700	107,540	50,360	28,760	Sometimes	Sometimes
-35	Yellow silt loam.....	15,340	2,050	3,000	540	113,300	71,560	99,040	Sometimes	Sometimes
(c) Terrace Soils (1500)										
-60	Brown sandy loam.....	35,130	3,210	1,920	810	70,860	19,800	15,780		
-26	Brown silt loam.....	34,500	3,780	3,300	1,140	120,480	44,880	29,340		
-71	Brown fine sandy loam.....	63,990	4,920	3,660	2,430	113,640	78,420	129,180	432,810	
-81	Dune sand.....	14,160	1,020	1,980	420	51,600	34,740	55,860	114,960	
-26.4	Brown silt loam on gravel.....	54,780	5,340	3,480	2,040	97,740	42,660	28,320		
-36	Yellow-gray silt loam over gravel.	15,660	2,760	3,720	840	117,600	35,940	21,300		540
-64	Yellow-gray sandy loam.....	20,400	3,000	4,740	300	114,480	36,120	21,180		
-64.4	Yellow-gray sandy loam on gravel	28,080	3,720	2,700	300	147,180	50,700	20,640		
-60.4	Brown sandy loam on gravel.....	43,560	3,900	2,460	1,380	84,420	22,980	19,020		
-28	Brown-gray silt loam on tight clay	29,220	3,840	2,880	480	160,800	58,560	22,860		300
(d) Old Swamp and Bottom-Land Soils (1300)										
-26	Deep brown silt loam.....	133,140	11,760	5,520	2,040	110,880	54,420	79,620	111,960	
-54	Mixed loam.....	126,240	9,960	4,620	2,040	113,880	40,140	52,500	38,520	
-01	Deep peat ²	872,580	51,450	2,850	18,960	4,980	18,450	551,550	1,207,710	
(e) Late Swamp and Bottom-Land Soils (1400)										
-26	Deep brown silt loam.....	71,940	6,390	3,330	1,260	115,290	57,570	93,900	Sometimes	
-54	Mixed loam.....	38,340	3,090	2,700	810	106,440	116,760	210,630	800,820	
-15	Drab clay.....	47,760	5,040	2,880	960	133,440	60,060	48,660	19,680	

¹Where neither carbonates nor acidity is reported it is understood that the soil is either neutral or so nearly neutral as to be within the limits of the experimental error of determination.

²Amounts reported are for 3 million pounds of deep peat.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Peoria county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. An important piece of information contained in these tables is that in the common upland soils limestone is seldom found, either in the surface, subsurface, or subsoil. These tables also show great stores of potassium and only limited amounts of phosphorus, in agreement with the data for the surface stratum presented in Table 2.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Peoria county occupy about 212 square miles, or 34 percent of the entire area of the county. They are black or brown in color owing to their large content of organic matter.

The accumulation of organic matter in the prairie soils is due to the growth of prairie grasses that once covered them. The network of roots formed by these grasses was protected from complete decay by the imperfect aeration resulting from the covering of fine soil material and the moisture it contained. On the native prairies these grasses were usually burned, but the roots accumulated in the soil. From a sample of virgin sod of "blue-stem," one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of seven inches contains as much as 13.5 tons of roots. Many of these roots died each year and by partial decay formed the humus of these dark prairie soils.

Brown Silt Loam (226, 526, 926, 1126)

Brown silt loam is the most extensive as well as the most important type in Peoria county. It covers an area of 208.75 square miles (133,600 acres), or 33.64 percent of the area of the county. This type occupies the undulating to slightly rolling prairie land. It is generally well surface-drained, yet artificial drainage is necessary on some of the flat land or in some of the draws. The morainal areas are sufficiently rolling in some parts to require care in preventing them from washing badly.

Brown silt loam is normally a prairie soil, yet in a few cases forests have recently invaded it. These forests consist quite largely of bur oak, black walnut, elm, and hard maple. A timber soil, so called, of this type is usually spoken of as a black walnut soil and is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter. After the growth of several generations of trees, the organic matter becomes so reduced that the soil is then classed as a true timber type.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, is a brown silt loam, varying on the one hand to black silty clay loam as the type grades into black clay loam, and on the other hand to grayish brown or yellowish brown as it grades into the timber type, yellow-gray silt loam (534 or 934). In physical composition it varies to a slight extent, but it is normally a silt loam containing from 65 to 80 percent of silt, from 10 to 20 percent of sand, and from 7 to 15 percent of clay. The amount of clay increases as the type approaches black clay loam (520 or 1120) and becomes greatest in the level, poorly-drained areas.

The organic-matter content of the surface stratum averages about 4.8 percent, or 48 tons per acre. It varies from 4.2 to 5.5 percent. The amount of organic matter is less in the more rolling areas than in the low and poorly-drained parts, owing to the fact that not only less vegetation grew on the drier, more rolling areas, but also that when incorporated with the soil much of it has been removed by erosion or has undergone more rapid decomposition because of the better aeration and the lower moisture content. As a rule, the early Wisconsin glaciation contains less organic matter than the upper Illinoian glaciation, the former containing 4.3 percent, while the latter contains an average of 5.2 percent, or about nine tons more per acre.

The natural subsurface varies from 6 to 18 inches in thickness, being thinner on the more rolling areas and decidedly thicker and darker on the more level parts. The top part of the subsurface is a brown silt loam. With depth, this stratum becomes more yellow, gradually passing into the yellow, more clayey subsoil. In physical composition it varies in the same way as the surface soil, but it usually contains a slightly larger amount of clay, especially as it approaches the black clay loam (520 or 1120). Both color and depth vary with topography, the stratum being lighter in color as well as shallower on the more rolling areas and where the type grades into the yellow-gray or the yellow silt loam (534 or 535). The amount of organic matter varies from 2.7 to 4.4 with an average of 3.3 percent, or 66 tons for a stratum 13 $\frac{1}{2}$ inches thick over an acre.

The natural subsoil begins at a depth of 13 to 24 inches and extends to an indefinite depth but is sampled to 40 inches. It varies with topography both in color and in texture and becomes slightly coarser with depth. It consists of a yellow or drabish mottled yellow clayey silt or silty clay, which is plastic when wet. The texture becomes slightly more silty at a depth of 30 to 36 inches. Where the drainage has been good, the subsoil varies from a bright to a pale yellow color, while with poor drainage it approaches a drab or an olive color with yellow mottlings or a pale yellow color with mottlings of drab.

Each stratum of brown silt loam is pervious, so that drainage takes place with little difficulty.

In the early Wisconsin glaciation, the deposit of loess is so thin in some areas where erosion has taken place, that the boulder clay constitutes part or all of the subsoil. This is not seriously detrimental to the soil, since the glacial drift is not so compact as to constitute a hardpan.

Small grayish patches which have a tight clay subsoil are found in this type. They are really small areas of brown-gray silt loam on tight clay (528) which are too small to be shown on the map. They usually occur where drainage is poor. The soil in these spots is cold, not readily pervious, and needs drainage and the incorporation of organic matter. Limestone is often beneficial. Such spots are commonly spoken of as "buffalo wallows."

Treatment.—While the common brown silt loam is in fair physical condition, yet continuous cropping to corn, or to corn and oats, with the burning of the stalks, is destroying the tilth; the soil is becoming more difficult to work; it runs together more; and aeration, granulation, and absorption of moisture do not take place as readily as formerly. This condition of poor tilth may become serious unless better methods of management are more generally adopted; it is already one of the factors that limits the crop yields. The remedy is to increase the organic-matter content by plowing under farm manure and crop residues, such as corn stalks, straw, and clover.

In all samples collected the laboratory tests indicate a lack of limestone. Field experiments in many instances show a beneficial effect upon crop production from the application of limestone. The analyses show only a moderate quantity of nitrogen in the surface soil. A good system of farming will require that the nitrogen be kept up. In the production of our ordinary field crops this is to be done thru the use of farm manures and the periodic growth of legume crops.

Phosphorus is present in but limited quantity; the permanent maintenance of this kind of soil therefore calls for the liberal application of this element of plant food. Numerous field experiments as well as common farm experience have demonstrated a great financial profit in the application of phosphorus to brown silt loam soil.

The analytical data show an abundant supply of potassium. It is important to note that numerous field experiments have shown no material benefit from the application of potassium in the production of our common field crops on this type of soil.

For an account of field experiments on this type of soil see page 41 of the Supplement.

Black Clay Loam (520, 1120, 1520)

Black clay loam represents the flat, poorly-drained prairie. The upland areas occur in the flat divides and are formed by the accumulation of organic matter and the washing in of fine material from the slightly higher surrounding lands. This type occupies 1.56 square miles (998 acres), or .25 percent of the area of the county. It is so flat that artificial drainage is nearly always necessary.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a black, plastic, granular clay loam, varying locally to a black clayey silt loam on the large, flat areas. The organic-matter content varies from 6 to 7 percent, with an average of 6.5 percent, or 65 tons per acre. In physical composition it varies toward the brown silt loam which always surrounds it.

The natural subsurface stratum has a thickness of 10 to 18 inches and varies from a black to a dark brown silty clay loam usually somewhat heavier than the surface soil. The amount of organic matter varies from 4.3 to 5.9 percent, with an average of 5.1 percent, or 102 tons per acre. The subsurface passes into a yellow or a drabbish yellow silty clay. The stratum is quite pervious to water, owing to the jointing, or checking, from shrinkage in times of drouth.

The subsoil to a depth of 40 inches varies from a drab to a yellowish drab or drabbish yellow silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration. The perviousness of the subsoil is about

the same as that of the subsurface, and is due to the same cause. When thrown out on the surface, as in the operation of ditching, it soon breaks into small cubical masses.

Treatment.—Drainage is the first requirement in the management of this type. Altho it usually has but little slope, yet because of its perviousness it is easily tile-drained. Keeping the soil in good physical condition is very essential, and thoro drainage helps to do this to a great extent. With the destruction of the organic matter thru decomposition and the removal of limestone by cropping and leaching, the soil becomes poorer in physical condition, and as a consequence it becomes more difficult to work. Both organic matter and limestone tend to develop granulation. The organic matter should be maintained by turning under manure or such crop residues as corn stalks and straw and by the use of clover and pasture in rotations. Ground limestone should be applied when needed to keep the soil sweet. It should be remembered that the difficulty of working clay soils is in proportion to their deficiency in organic matter.

While black clay loam is one of the best soils in the state, yet the clay and humus which it contains give it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, these constituents expand, and when the moisture evaporates or is used by the crops, they shrink. This results in the formation of cracks which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil strata to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Both for aeration and as a means of producing a mulch for conserving moisture, cultivation is more essential on this type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the corn.

The results of field experiments on this type of soil are given on page 49 of the Supplement.

Brown-Gray Silt Loam on Tight Clay (528, 928)

Brown-gray silt loam on tight clay occurs in small areas, mostly in Town 11 North, Range 7 East, and occupies 1.47 square miles (941 acres), or .24 percent of the area of the county.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, is a brown to slightly grayish brown silt loam, and contains 3.8 percent of organic matter, or 38 tons per acre.

The subsurface stratum consists of a brownish gray to a grayish silt loam which passes into tight clay at a depth of 16 to 18 inches. The subsurface contains 1.8 percent of organic matter, or 36 tons per acre in a stratum twice the thickness of the surface.

The subsoil consists of a tight, tough, plastic clay of a brownish yellow to a yellow color.

Treatment.—The type, as a general rule, needs drainage. This condition in the northern part of the county seems to be due to seepage water that is brought to the surface by means of some tight stratum. Practically all this type may

be benefited by the growing of deep-rooting crops and the incorporation of organic matter. As the lower strata of this type are acid, in order to grow clover satisfactorily it is advisable to apply limestone rather liberally, say 4 tons per acre as an initial application and about $1\frac{1}{2}$ tons every four or five years thereafter.

The soil may be greatly improved by turning under crop residues and clover along with about a ton of rock phosphate to the acre, as an initial application and a half ton at intervals of four or five years thereafter.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on the steeper parts of morainal ridges. They are characterized by a yellow, yellowish gray, or gray color, which is due to the low organic-matter content (organic matter imparting dark colors). The gray is due to the lack of the higher oxides of iron which give the brighter reds and yellows. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies two effects were produced: first, the shading of the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until in some parts of the state a low condition of apparent equilibrium has been reached. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils comprize 300.72 square miles, or 48.46 percent of the entire area of the county.

Yellow-Gray Silt Loam (234, 534, 934, 1134)

Yellow-gray silt loam occurs principally as the outer timber belt along streams. The type covers 128.13 square miles (82,003 acres), or 20.65 percent of the area of the county. In topography it is sufficiently rolling for good surface drainage without much tendency to wash if proper care is taken.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a yellow, yellowish gray, or gray to brownish gray silt loam, incoherent and pulverulent but not granular. The more nearly level areas are gray in color, while the more rolling phase of the type has a yellow or a brownish yellow color. After rains this soil usually has a grayish tint. As the type approaches brown silt loam, it becomes decidedly darker. The organic-matter content averages about 2.1 percent, or 21 tons per acre. The variation is from 2 to 2.3 percent, and is chiefly due to differences in topography, being less in the more rolling parts, where some erosion has taken place.

The natural subsurface stratum varies from 8 to 10 inches in thickness. It is usually a gray, grayish yellow, or yellow silt loam, becoming somewhat plastic at depths of 14 to 17 inches. The amount of organic matter is .7 percent. In this type there is almost invariably a decided decrease in the organic-matter content at a depth of about 7 or 8 inches.

The subsoil is a yellow or mottled grayish yellow clayey silt or silty clay, somewhat plastic when wet but friable when only moist. It is pervious to water. The map shows the presence of this type on two glaciations, the early Wisconsin and the upper Illinoian. The type does not vary much, but on the early Wisconsin glaciation glacial drift is sometimes encountered at a depth of less than 40 inches, while it rarely ever forms the subsoil on the upper Illinoian. This is due to the fact that the layer of wind-blown loess formed a thicker deposit on the Illinoian than on the Wisconsin glaciation.

Treatment.—In the management of this yellow-gray silt loam, one of the most essential points is the increasing of the organic-matter content. This is necessary in order to supply nitrogen, to liberate mineral plant food, to give better tilth, to prevent running together, and on some of the more rolling phases, to prevent washing.

Another essential in some localities is that the acidity of the soil be neutralized by the application of ground limestone, so that clover, alfalfa, and other legumes may be grown more successfully. An initial application of 2 to 4 tons per acre is suggested, after which one or two tons per acre every four or five years will be sufficient. Since the soil is poor in phosphorus, this element should be applied. In permanent systems of farming, finely ground natural rock phosphate will usually be found the most economical form in which to supply the phosphorus, altho when prices are favorable steamed bone meal or acid phosphate may well be used temporarily until plenty of decaying organic matter can be provided.

The rotation established on this type should be such that legumes are grown frequently, at least till the organic matter and nitrogen are increased to a considerable extent. A good four-year rotation is corn, oats, clover, and wheat, with a seeding of clover to be plowed under the next spring for corn.

See page 50 of the Supplement for an account of field experiments on this type of soil.

Yellow Silt Loam (235, 535, 935, 1135)

Yellow silt loam covers an area of 172.59 square miles (110,458 acres), or 27.81 percent of the area of the county. It occurs as the hilly and badly eroded land of the inner belt along streams, usually only in narrow irregular strips with arms extending up the small valleys. In topography it is very rolling, and in most places so badly broken that it should not be cultivated because of the danger of injury from washing.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, is a yellow or grayish yellow pulverulent silt loam. It varies greatly in color and texture, owing to recent washing, so that in places the natural yellow subsoil may be exposed. In other places it may be rather brown in color, indicating a good soil. When freshly plowed, the soil appears yellow or brownish yellow, but when it becomes dry after a rain it is of a grayish yellow color. In some places the surface soil is formed from glacial drift, but this is only on very limited areas on the steepest slopes and more commonly on the early Wisconsin deposits than on the Illinoian. The gravelly character of the early Wisconsin deposit frequently gives small areas of gravelly loam in this type. The organic-matter content varies from 1.2 to 2.5 percent, the average being about 1.5 percent, or 15 tons per acre, the lowest of any type in the county except that of dune sand.

The subsurface varies from a yellow silt loam or a yellow clayey silt loam to a yellow gravelly material. The latter is found more commonly in the early Wisconsin glaciation. The thickness of the natural subsurface stratum varies from 2 to 10 inches. The organic-matter content is .7 percent, or 14 tons per acre in a stratum $13\frac{1}{3}$ inches thick.

The subsoil in the Illinoisan glaciation is normally a yellow clayey silt, while in the early Wisconsin it is frequently composed entirely of glacial drift with varying amounts of gravel and sand.

Treatment.—The first and most important point in the management of this type is the prevention of general surface-washing and gullying. If the land is cropped at all a rotation should be practiced that will require cultivated crops as little as possible and allow pasture and meadow most of the time. If tilled, the land should be plowed deeply and contours should be followed as nearly as possible in plowing, planting, and cultivating. Furrows should not be made up and down the slopes. Every means should be employed to maintain and to increase the organic-matter content. This will help to hold the soil and keep it in good physical condition so that it will absorb a large amount of water and thus diminish the run-off.

On very steep land where cultivation is not possible and the timber has been removed, permanent pasture of blue grass and sweet clover should be maintained. This makes an especially good combination, because the sweet clover furnishes nitrogen for the use of the blue grass, and the two together hold the soil so that washing cannot take place.

Additional treatment that is likely to be needed for this yellow silt loam is the use of limestone wherever cropping is practiced. This type is sometimes acid, especially in the surface layer; and the limestone by correcting the acidity of the soil is especially beneficial to the clover grown to increase the supply of nitrogen. Where this type has been long cultivated and thus exposed to surface-washing it is particularly deficient in nitrogen; indeed on such lands the low supply of nitrogen is the factor that first limits the growth of grain crops.

For an account of some experimental tests on this type of soil the reader is referred to page 53 of the Supplement and also to Bulletin 207.

(c) TERRACE SOILS

Terrace soils were formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from an overloaded and flooded stream during the melting of the glaciers. The material varies from fine to coarse. These valleys were sometimes filled almost to the height of the upland. Later the streams cut down thru these fills and developed new bottom lands, or flood plains, at a lower level, leaving part of the old fill as a terrace. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom. Finer material later deposited on this sand and gravel of the fill now constitutes the soil. Along some of the streams the fill seems to have been made almost entirely of fine silty material. This is true of the terraces along the Senachwine creek in the northeastern part of the county. The amount of gravel deposited here is very small.

Brown Sandy Loam (1560)

Brown sandy loam covers 16.66 square miles (10,663 acres), or 2.68 percent of the area of the county. The topography is mostly flat, with slight undulations that probably have been produced by the wind. The type occurs principally in the northeastern part of the county in the vicinity of Chillicothe. The city of Peoria is located on another of the largest areas. Smaller areas occur along Kickapoo creek.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a brown sandy loam containing about 2 percent of organic matter, or 20 tons per acre.

The subsurface is a brown sandy loam varying in thickness from 6 to 12 inches. The organic-matter content is about 1.7 percent, or 34 tons per acre in a stratum twice the thickness of the plowed soil.

The subsoil is yellow and varies from sand to a silty sand.

Treatment.—As a general rule the drainage of this type is good, but in some cases artificial drainage may be necessary.

In the management of this type it is very necessary that the organic-matter content be increased, since the type is low in this constituent. Crop residues, manure, and legumes should be turned under. The application of limestone will sometimes be necessary in order to obtain good results with clover since all strata lack limestone. The type is low in phosphorus. A ton of rock phosphate applied at first, with about one-half ton every four or five years thereafter, will soon replenish the soil in this essential plant food.

Brown Silt Loam (1526)

Brown silt loam covers an area of 6.57 square miles (4,205 acres), or 1.06 percent of the area of the county. It occupies a lower part of the terrace near the bluff, principally in the northeastern part, and very likely represents an old abandoned river channel which has since been partly filled with fine material washed in by the streams from the upland.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a brown to black silt loam containing a variable amount of fine sand which in some cases is present in sufficient quantity to produce a fine sandy loam. The organic-matter content is about 3.6 percent, or 36 tons per acre.

The natural subsurface stratum is a brown silt loam varying from 10 to 16 inches in thickness. The subsurface as sampled contains 2.4 percent of organic matter, or 48 tons in a stratum $13\frac{1}{3}$ inches thick.

The subsoil varies from a drab or brownish drab to yellow clayey silt.

Treatment.—All strata are pervious to water, and this provides excellent conditions for underdrainage. It is likely that this type is underlain by sand or gravel, but at such a great depth that it has very little effect on the drainage of the soil. This type is alluvial, and still receives a small amount of deposit on certain parts that adds fertility to it; so the necessity of soil treatment is not so great as if it received no deposit. However, on the parts that do not overflow or receive any deposit from the upland, the maintaining of the organic matter is very important, and the same methods should be used as are recommended for the brown silt loam of the upland already described.

Brown Fine Sandy Loam (1571)

Brown fine sandy loam occurs at the base of the bluff of the Illinois river and is formed by the material washed from the upland. Much of this adjacent upland is of loessial character, containing large amounts of fine sand, and when this is carried down by the small streams, this type is formed. The type covers 4.49 square miles (2,874 acres), or .72 percent of the area of the county. The situation with respect to location and drainage is about the same as that of the brown silt loam (1526).

The surface soil, 0 to $6\frac{2}{3}$ inches, is a brown fine sandy loam, the content of sand varying from 50 to 65 percent. The organic-matter content is about 3 percent, or 30 tons per acre. This type varies toward brown silt loam and passes gradually into that type, so that the line between the two is not distinct.

The natural subsurface forms a layer varying from 10 to 14 inches in thickness and is slightly heavier than the surface stratum. In some places the lower depths of the subsurface become quite heavy.

The subsoil varies in color from a yellow to a yellowish drab. It is mostly a silty clay or clayey silt.

Treatment.—All strata are pervious to water, drainage taking place quite readily. The type needs the same treatment as brown silt loam (1526) except that limestone is naturally present here and only sufficient phosphorus need be added to maintain the present supply.

Dune Sand (1581)

The area of dune sand is confined entirely to the terrace in the northeastern part of the county in the vicinity of Chillicothe. When the terrace was formed, the water of the river was much higher than at the present time, and the sand which was carried and deposited by the stream was re-worked by the wind and now constitutes the dunes. This type occupies 2.81 square miles (1,798 acres), or .45 percent of the area of the county. The dunes vary in height from a few feet to as much as 50 feet and are very irregularly distributed. Probably because of the irregularity of the winds, these dunes rarely present what is a normal dune formation; that is, they do not have the usual gradual windward slope and abrupt leeward slope.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a loamy sand varying from a yellowish to a brownish color and containing .9 percent of organic matter, or 9 tons per acre. The texture of the sand is quite uniform, being mostly of the medium grade. The dunes have never been timbered.

The subsurface consists of a yellow to slightly brownish yellow sand. It contains about the same percentage of organic matter as the surface stratum, due to the fact that plants growing on this type distribute their roots rather uniformly to a greater depth than they do on other types. The sand is principally of medium grade.

The subsoil is a yellow sand.

Condition.—In this county there would be very little blowing of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are simply small areas from which the sand is being blown. The action of the wind may result in the ruin of the land if some protection

is not given it. Wind erosion on this soil is worse than water erosion on other soils. Sand possesses very little cohesion, and is therefore readily moved by the wind. When organic matter is added this acts as a feeble cement, which serves to bind the particles together and prevent blowing.

Treatment.—In the management of this type, the principal problems are to prevent blowing and to maintain the supply of nitrogen. Fortunately the best method for preventing blowing will also supply nitrogen. To prevent the movement of sand by the wind it is necessary either to have windbreaks, or to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing blowing. Every means should be used for increasing the organic matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn.

The plants that are best adapted to sand dunes are legumes, which to a very large extent are independent of the nitrogen in the soil. It is interesting to know that a few legumes have adapted themselves to the sand to a remarkable degree. The climbing wild bean is a legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases a ton or more to the acre is produced. It would seem that this plant might well be distributed over all the sand areas, especially those that are likely to blow.

Cowpeas are well adapted to growing on these sand soils. They furnish a large amount of organic matter to hold the sand and also the necessary nitrogen for growing other crops. Where wheat or rye is grown, the drill, with peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and the wheat seeded in them, leaving the vines to protect the sand during the winter. Recent experiments show that two of the best crops for sand are sweet clover and alfalfa.

In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly spoken of by farmers as "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is more often due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will do much to prevent firing.

In the management of a crop on sandy land, cultivation should be practiced no more than is absolutely necessary and should then be as shallow as possible. Sand is naturally well adapted to prevent moisture from evaporating, and there is no necessity for any more cultivation than is really necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Forestry is a practical way of conserving these sand soils. The black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty with this tree, however, is that it is damaged by borers; but if it is used to start a growth and hold the sand, other trees may then be grown

and the result will be that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, so that the grass will not be entirely destroyed.

With respect to the acidity, analysis shows limestone to be lacking in the surface and subsurface. For satisfactory results, therefore, an application of 2 to 4 tons per acre of limestone is recommended, and the supply should be maintained by subsequent applications every four or five years.

As the nitrogen content is exceedingly low, successful crop production rests upon the building up of the supply of this element, and this is to be accomplished thru the growing of legumes, as recommended above.

The phosphorus content of sand soils is not high, there being only 680 pounds of this element per acre in the plowed soil, but it exists to a considerable extent in other constituents than sand grains. The United States Bureau of Soils separated two types of sandy soil—glacial sand and sandy loam—into coarse, medium, and fine particles, analyzed each grade for phosphorus, and found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, such a limited amount of phosphorus would, however, sooner or later, become exhausted, altho field experiments on sandy soil might not indicate a need of this element at first.

The total supply of potassium is large, but as to its availability for growing crops field experiments on sandy soil have shown some discrepancies in results, owing probably to a variation in the condition in which the potassium exists. Definite recommendations, therefore, regarding the application of potassium to this type of soil must await the collection of more reliable information. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

For an account of field experiments on dune sand see page 55 of the Supplement.

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occupies 4.78 square miles (3,059 acres), or .77 percent of the area of the county. It occurs in the northeast part of the county immediately around Chillicothe. It varies in topography from flat to rolling.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a brown to yellowish brown silt loam, containing more or less sand. Small areas occur that are sufficiently sandy to be classed as sandy loam, but these are not large enough to be shown on the map. Occasionally gravel and even stones are found in the surface soil. On some of the steepest slopes the gravel is exposed, giving a silty gravelly loam. The organic-matter content is 3 percent, or 30 tons per acre.

The natural subsurface soil varies in thickness, depending upon the depth to gravel, which varies from 16 to 24 inches, with an average depth of about 20 to 22 inches.

The subsoil consists mostly of gravel mixed with small stones which vary to 2 inches in diameter.

Treatment.—The proximity of gravel to the surface renders the soil a somewhat inferior one, because of the effect during drouth. Alfalfa does well

on the type and because of its deep-rooting characteristic is much to be preferred to corn. The same precautions must be taken in maintaining the organic-matter content as are necessary for the upland brown silt loam, and if this constituent is kept supplied to the soil, the injurious effect of drouth will not be so great. An application of 2 tons of ground limestone should be made to enable legumes to be grown more successfully. Applications of rock phosphate are recommended in view of the fact that the soil is not high in phosphorus content.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-gray silt loam over gravel occurs almost entirely along the smaller streams of the county, and represents old fl's or terraces of fine material. The type occupies 3.34 square miles (2,138 acres), or .54 percent of the area of the county. These terraces lie from 25 to 75 feet or more above the stream, and are usually undulating in topography.

The surface soil, 0 to $6\frac{2}{3}$ inches, consists of a yellow to yellowish gray silt loam, and contains 2.1 percent of organic matter, or 21 tons per acre.

The subsurface is a yellow silt loam, becoming slightly heavier with depth. It contains .8 percent of organic matter.

The subsoil differs but little from the subsurface in either color or texture.

Treatment.—The type requires the same treatment as the upland yellow-gray silt loam (534).

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam occurs along the Illinois river in the southern part of the county. It occupies 1.91 square miles (1,222 acres), or .31 percent of the total area of the county.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a yellow to brownish yellow sandy loam containing 2 percent of organic matter, or 20 tons per acre. Its sand content is not large enough to make it very light.

The subsurface consists of a yellow sandy loam, which becomes lighter with depth.

The subsoil is irregular in texture, in some places consisting of sand and in others of sandy silt.

Treatment.—The treatment should be the same as for the upland yellow-gray silt loam (534).

Yellow-Gray Sandy Loam on Gravel (1564.4)

Only a few small areas of yellow-gray sandy loam on gravel occur in the county, all of them together covering only 102 acres.

The surface varies considerably in texture, sometimes merging into a silt loam. It also varies in color and organic-matter content. It contains about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a yellow or brownish yellow sandy loam, with 1.4 percent of organic matter.

The subsoil is a yellow to grayish yellow sandy silt to slightly silty sand, passing into gravel at depths varying from 20 to 30 inches.

Treatment.—The type requires the same treatment as the yellow-gray silt loam of the upland (534).

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel covers .41 square miles (262 acres) and occurs on the terrace in the northeast part of the county.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, contains 2.8 percent of organic matter and consists of a brown sandy loam containing more or less gravel.

The subsurface contains 2.5 percent of organic matter and differs but little from the surface soil either in texture or in color.

The subsoil is composed almost entirely of gravel, which begins at depths varying from 16 to 24 inches.

Treatment.—This type requires that the organic-matter content be maintained. Rock phosphate should be applied at the rate of $\frac{1}{2}$ to $\frac{3}{4}$ ton per acre every four or five years.

Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay occurs in small areas on the terrace in the northeast part of the county. It covers only .18 square miles, or 115 acres.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, is brown to grayish in color, containing small spots much lighter in color than the average. It contains 3.7 percent of organic matter, or 37 tons per acre.

The natural subsurface, which varies from 6 to 10 inches in thickness, is a grayish silt loam, very friable and rather impervious. It contains 1.4 percent of organic matter. This is immediately underlain by a tight clay of a brownish yellow color, which is very impervious to water, thus interfering seriously with drainage. This tight stratum is from 10 to 16 inches thick. A more open stratum is found beneath.

Treatment.—The type needs drainage first, then heavy applications of limestone, and deep-rooting crops to open up the subsoil.

(d) OLD SWAMP AND BOTTOM-LAND SOILS

Deep Brown Silt Loam (1326)

Deep brown silt loam occurs in the western and northern parts of the county along the small streams, and covers an area of 8.41 square miles (5,383 acres), or 1.35 percent of the area of the county.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, is a brown silt loam varying toward sandy loam. It contains 3.6 percent of organic matter.

The subsurface is a brown silt loam, and in the sample collected contained slightly more organic matter than was found in the surface stratum.

The subsoil, 20 to 40 inches, is a brown silt loam containing the same percentage of organic matter as the surface. This peculiarity in the organic-matter content has been produced by the burying of considerable quantities of organic matter in the deposition of sediment during overflow. The sediment also carries some organic matter.

Treatment.—Because of the occasional deposition of new material, little need be done beyond good cultivation, in keeping up the productiveness of this soil.

Mixed Loam (1354)

Mixed loam occurs along the streams in the southern part of the county in the Illinoisan glaciation. It covers an area of 38.40 square miles (24,576 acres), or 6.19 percent of the area of the county.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, varies so much that it is impossible to separate it into distinct types. In some places there are small areas of sand, in others sandy loam, in others silt loam, and during flood times the areas may be changed entirely, so that it is impracticable to map separate types. The analysis gave 2.4 percent as the organic-matter content.

The subsurface varies with the surface and contains about the same amount of organic matter.

The subsoil varies even to a greater extent than the other strata. The sample which was taken contained more organic matter than either the surface or the subsurface. This can be accounted for in the same way as in the preceding type.

Treatment.—No special soil treatment is recommended.

Deep Peat (1301)

The total area of this type in the county is only 38 acres.

The surface soil contains 36 percent of organic matter, or 180 tons per acre for 1,000,000 pounds of plowed soil. *The subsurface* is very similar to the surface, but contains 48 percent of organic matter. *The subsoil* contains 50 percent of organic matter.

(e) LATE SWAMP AND BOTTOM-LAND SOILS

Deep Brown Silt Loam (1426)

Deep brown silt loam covers 9.55 square miles (6,112 acres), or 1.54 percent of the area of the county. It occurs almost entirely along the Illinois river and represents the later deposit.

The surface soil contains about 4.3 percent of organic matter, or 43 tons per acre and is of a dark brown to black color. In texture it varies, becoming almost heavy enough for clay loam in some small areas. This type is seldom very sandy, as it is usually formed in back water and away from the main currents of the river.

The subsurface soil is lighter in color than the surface, containing only 3 percent of organic matter.

The subsoil varies from drab to drabbish yellow, and contains 2 percent of organic matter.

Treatment.—Good cultivation to keep down the weeds is about all that can be done for this type where it is subject to occasional overflow. In case it is leveed, means ought to be taken to maintain the fertility.

Mixed Loam (1454)

Mixed loam occurs as bottom land along the smaller streams and where these streams carry material on to the terrace or larger bottom lands. The soils are so mixed that it would be practically impossible to separate them into different types.

The surface soil contains approximately 3.8 percent of organic matter, or 38 tons per acre, and varies from a sand to a clay loam.

The subsurface soil contains about 2.2 percent of organic matter.

The subsoil is of a yellowish or drabbish color and contains about 1.1 percent of organic matter.

Drab Clay (1415)

In the southern part of the county the bottom land contains several areas of drab clay. The total area amounts to 4.64 square miles (2,970 acres), or .75 percent of the area of the county.

The surface soil, 0 to 6 $\frac{2}{3}$ inches, is a granular, plastic clay of a dark drab to almost black color. It contains 4.2 percent of organic matter.

The natural subsurface constitutes a layer about 13 inches in thickness. It is a drab, plastic clay, containing 2.1 percent of organic matter.

The subsoil does not differ greatly from the surface except that it becomes lighter in color. It still retains, however, the drab or bluish color which results from a lack of the higher oxids of iron.

Treatment.—This type is usually pervious to water because of the cracking which has taken place during periods of drouth. It is difficult to work because of the danger of puddling if too wet and the formation of clods when it becomes dry. In order to maintain the best working qualities, organic matter must be added to the soil. This will make it less readily puddled, and will promote granulation. An occasional application of limestone will probably be beneficial.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolian, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

- 100 *Unglaciated*, comprizing three areas, the largest being in the south end of the state
- 200 *Illinoisan moraines*, including the moraines of the Illinoisan glaciation
- 300 *Lower Illinoisan glaciation*, covering nearly the south third of the state
- 400 *Middle Illinoisan glaciation*, covering about a dozen counties in the west-central part of the state
- 500 *Upper Illinoisan glaciation*, covering about fourteen counties northwest of the middle Illinoisan glaciation
- 600 *Pre-Iowan glaciation*, but now believed to be part of the upper Illinoisan
- 700 *Iowan glaciation*, lying in the central northern end of the state
- 800 *Deep loess areas*, including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
- 900 *Early Wisconsin moraines*, including the moraines of the early Wisconsin glaciation
- 1000 *Late Wisconsin moraines*, including the moraines of the late Wisconsin glaciation
- 1100 *Early Wisconsin glaciation*, covering the greater part of the northeast quarter of the state
- 1200 *Late Wisconsin glaciation*, lying in the northeast corner of the state
- 1300 *Old river bottom and swamp lands*, found in the older or Illinoisan glaciation
- 1400 *Late river bottom and swamp lands*, those of the Wisconsin and Iowan glaciations
- 1500 *Terraces*, formed by overloaded streams draining from the glaciers and gravel outwash plains
- 1600 *Lacustrine deposits*, formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9.....	Peats
10 to 12.....	Peaty loams
13 to 14.....	Mucks
15 to 19.....	Clays
20 to 24.....	Clay loams
25 to 49.....	Silt loams
50 to 59.....	Loams
60 to 79.....	Sandy loams
80 to 89.....	Sands
90 to 94.....	Gravelly loams
95 to 97.....	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois*. The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6 $\frac{2}{3}$ inches), the subsurface (6 $\frac{2}{3}$ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and land-owners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron*; and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
Wheat, grain.	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw.	1 ton	10.00	1.60	2.70	18.00	1.60	4.10	.60
Corn, grain.	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	7.00
Corn cobs.	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.	1 bu.	.66	.11	.06	.16	.04	.02	.02
Oat straw.	1 ton	12.40	2.00	4.14	20.80	2.80	6.15	6.00
Clover seed.	1 bu.	1.75	.50	.....	.75	.25	.25	.....
Clover hay.	1 ton	40.00	5.00	3.28	30.00	7.75	29.50	29.25

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen, and hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen*, one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron, and sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure.....	10	2	8
Corn stover.....	16	2	17
Oat straw.....	12	2	21
Wheat straw.....	10	2	19
Clover hay.....	40	5	30
Cowpea hay.....	43	5	33
Alfalfa hay.....	50	4	24
Sweet clover (water-free basis) ¹	80	8	28
Dried blood.....	280	...	...
Sodium nitrate.....	310	...	...
Ammonium sulfate.....	400	...	...
Raw bone meal.....	80	180	...
Steamed bone meal.....	20	250	...
Raw rock phosphate.....	...	250	...
Acid phosphate.....	...	125	...
Potassium chlorid.....	...	...	850
Potassium sulfate.....	...	...	850
Kainit.....	...	...	200
Wood ashes ²	...	10	100

¹Young second year's growth ready to plow under as green manure.

²Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6 $\frac{2}{3}$ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen*. As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one of nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the sub-surface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply about 2 tons per acre of ground limestone every four or five years, using preferably at times magnesian limestone ($\text{CaCO}_3\text{MgCO}_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone (CaCO_3). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying the litmus-paper test for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid.

Following are the directions for making these tests:

To test for soil acidity, make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. To make a thoro examination, samples should be tested from the surface and from the subsoil at different places in the field. Needless to say the reliability of the test depends upon the quality of litmus paper used.

To make the test for carbonates, make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxide, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

- 1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
- 1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
- 1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
- 1 ton of timothy requires 24 pounds of nitrogen.
- 1 ton of clover contains 40 pounds of nitrogen.
- 1 ton of cowpeas contains 43 pounds of nitrogen.
- 1 ton of alfalfa contains 50 pounds of nitrogen.
- 1 ton of average manure contains 10 pounds of nitrogen.
- 1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullyng) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphorus containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6 $\frac{1}{2}$ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate (CaCO_3), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxide gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

- First year* —Corn
- Second year* —Corn
- Third year* —Wheat or oats (with clover or clover and grass)
- Fourth year* —Clover, or clover and grass
- Fifth year* —Wheat (with clover) or grass and clover
- Sixth year* —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

- First year* —Corn
- Second year* —Wheat or oats (with clover, or clover and grass)
- Third year* —Clover, or clover and grass
- Fourth year* —Wheat (with clover), or clover and grass
- Fifth year* —Clover, or clover and grass

- First year* —Corn
- Second year* —Corn
- Third year* —Wheat or oats (with clover, or clover and grass)
- Fourth year* —Clover, or clover and grass
- Fifth year* —Wheat (with clover)

- First year* —Corn
- Second year* —Cowpeas or soybeans
- Third year* —Wheat (with clover)
- Fourth year* —Clover
- Fifth year* —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Peoria County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system*, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system*.

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

- 0 = Untreated land or check plots
- M = Manure (animal)
- R = Residues (from crops, and includes legumes used as green manure)
- L = Limestone
- P = Phosphorus
- K = Potassium (usually in the form of kainit)
- N = Nitrogen (usually in the form contained in dried blood)
- () = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: CROP YIELDS IN SOIL EXPERIMENTS
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879-87	None.....	....	....	....	....	....	....
1888	None.....	54.3	49.5	....	....	48.6	....
1889	None.....	43.2	....	37.4	....	....	(4.04)
1890	None.....	48.7	54.3	....	....	....	(1.51)
1891	None.....	28.6	33.2	....	....	....	(1.46)
1892	None.....	33.1	....	37.2	70.2	....	....
1893	None.....	21.7	29.6	....	34.1	....	....
1894	None.....	34.8	....	57.2	....	65.1	....
1895	None.....	42.2	41.6	....	....	22.2	....
1896	None.....	62.3	....	34.5	....	....	....
1897	None.....	40.1	47.0	....	....	....	....
1898	None.....	18.1	....	....	....	....	....
1899	None.....	50.1	44.4	....	53.5	....	....
1900	None.....	48.0	....	41.5	....	....	....
1901	None.....	23.7	33.7	....	34.3	....	....
1902	None.....	60.2	....	56.3	....	54.6	....
1903	None.....	26.0	35.9	....	....	....	(1.11)
1904	None.....	21.5	....	17.5	55.3	....	....
1904	MLP.....	17.1	....	25.3	72.7	....	....
1905	None.....	24.8	50.0	....	....	42.3	....
1905	MLP.....	31.4	44.9	....	....	50.6	....
1906	None.....	27.1	....	34.7	....	....	(1.42) ¹
1906	MLP.....	35.8	....	52.4	....	....	(1.74) ¹
1907	None.....	29.0	47.8	....	80.5	....	....
1907	MLP.....	48.7	87.6	....	93.6	....	....
1908	None.....	13.4	....	32.9	....	40.0	....
1908	MLP.....	28.0	....	45.0	....	44.4	....
1909	None.....	26.6	33.0	....	....	....	(.65) ²
1909	MLP.....	31.6	64.8	....	....	....	(1.73) ³
1910	None.....	35.9	....	33.8	58.6	....	....
1910	MLP.....	54.6	....	59.4	83.3	....	....
1911	None.....	21.9	28.6	....	....	20.6	....
1911	MLP.....	31.5	46.3	....	....	38.0	....
1912	None.....	43.2	....	55.0	....	....	16.3 ¹
1912	MLP.....	64.2	....	81.0	....	....	20.0 ¹
1913	None.....	19.4	29.2	....	33.8	....	....
1913	MLP.....	32.0	25.0	....	47.8	....	....
1914	None.....	31.6	....	33.6	....	39.6	....
1914	MLP.....	39.4	....	58.2	....	60.4	....
1915	None.....	40.0	49.0	....	....	....	24.2 ¹
1915	MLP.....	66.0	81.2	....	....	....	27.1 ¹
1916	None.....	11.2	....	37.5	27.8	....	....
1916	MLP.....	10.8	....	64.7	40.6	....	....
1917	None.....	40.0	48.4	....	....	68.4	....
1917	MLP.....	78.0	81.4	....	....	86.9	....
1918	None.....	13.6	....	27.2	....	....	(2.58)
1918	MLP.....	32.6	....	59.3	....	....	(4.04)
1919	None.....	24.0	30.8	....	52.2	....	....
1919	MLP.....	43.4	66.2	....	70.8	....	....
1920	None.....	28.2	....	37.2	....	52.2	....
1920	MLP.....	54.4	....	51.6	....	69.7	....

¹Soybeans.

²In addition to the hay, .64 bushel of seed was harvested.

³In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
1888 to 1903	None.....	16 crops 39.7	9 crops 41.0	6 crops 44.0	4 crops 48.0	4 crops 47.6	4 crops (2.03)
1904 to 1920	None..... MLP.....	17 crops 26.6 41.1	8 crops 39.6 62.2	9 crops 34.4 55.2	6 crops 51.4 68.1	6 crops 43.9 58.3	3 crops (1.55) ¹ (2.50) ¹

¹One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.



FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops (**Le**), such as cowpeas and clover, were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops.

Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons of manure have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0.....	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R.....	57.1	52.3	28.7	1.47 ¹	19.8	(2.46)
3	M.....	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL.....	64.8	55.6	31.4	1.61 ¹	20.3	(2.72)
5	ML.....	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP.....	71.5	69.8	43.0	2.29 ¹	23.5	(3.69)
7	MLP.....	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK.....	70.9	72.5	40.7	1.79 ¹	25.5	(3.77)
9	MLPK.....	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5.....	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

¹In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

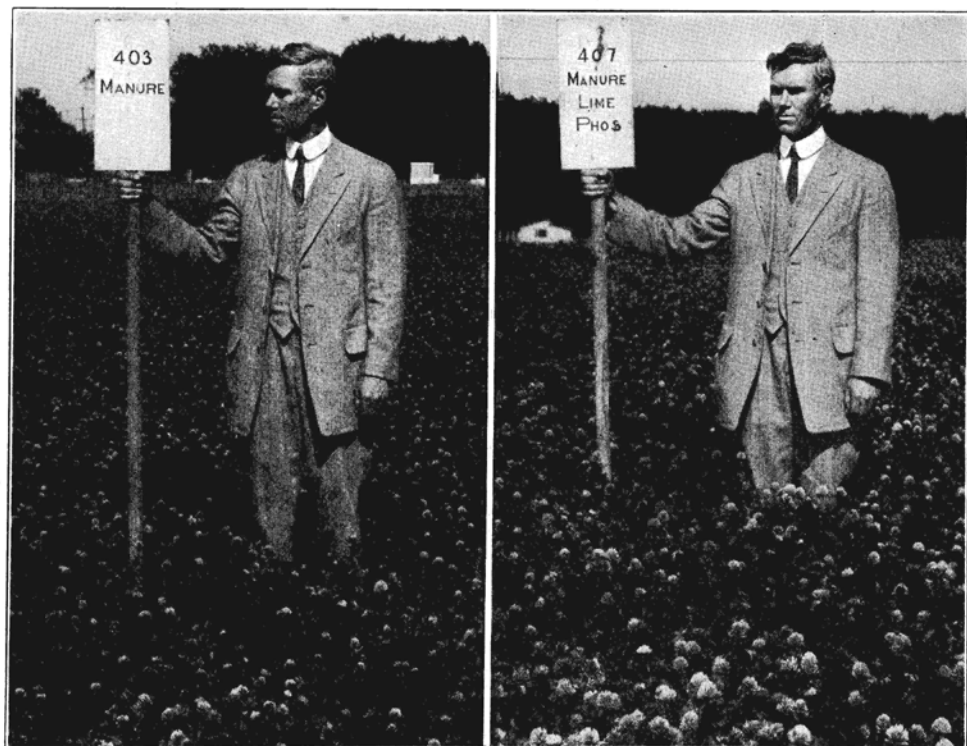
Potassium (K=kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system*, in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system*, in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400 ¹ : Wheat, Corn, Oats, Clover ²					
Soil treatment applied ⁶	Corn 9 crops	Oats ³ 9 crops	Wheat ³ 8 crops	Clover ⁴ 3 crops	Soybeans 7 crops
RP.....	62.3	51.9	41.0	1.05	17.3 ⁵
R.....	51.9	46.5	26.9	1.38	16.2 ⁵
M.....	59.7	50.2	29.1	(2.28)	(1.25)
MP.....	64.3	55.4	43.1	(2.86)	(1.51)
RLP.....	60.5	57.2	41.8	.64	16.4 ⁵
R.....	49.7	49.6	25.8	.83	14.7 ⁵
M.....	55.5	54.1	27.8	(1.71)	(1.28)
MLP.....	64.1	59.6	43.9	(1.77)	(1.58)
North-Central Rotation: Series 500, 600, 700 ¹ : Corn, Corn, Oats, Clover ²					
Soil treatment applied ⁶	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP.....	56.7	51.1	56.1	.54	16.9
R.....	51.7	45.2	52.0	.50	16.0
M.....	54.9	46.7	52.1	(2.29)	(1.60)
MP.....	56.5	53.4	56.9	(2.73)	(1.74)
South-Central Rotation: Series 500, 630, 700 ¹ : Corn, Corn, Corn, Soybeans					
Soil treatment applied ⁶	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP.....	51.9	44.0	41.3		20.0
R.....	45.5	39.9	35.2		19.2
M.....	50.1	42.1	33.5		(1.59)
MP.....	54.5	46.7	42.0		(1.66)

¹Results from Series 300 and 800 are omitted on account of variation in soil type.

²Soybeans when clover fails.

³Only seven crops with limestone.

⁴Only one crop with limestone.

⁵Average of five crops.

⁶All phosphorus plots received $\frac{1}{2}$ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume ¹	Corn-corn-oats-legume ²		Corn-corn-corn-legume ³		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus .	63.2	56.6	52.3	53.2	45.3	41.6

¹Clover 3 crops, and soybeans 7 crops.

²Clover 5 crops, and soybeans 5 crops.

³Soybeans 9 crops.

On the whole, the “residues” have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.



Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoian glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 6. The table also summarizes the yields, by crops, for the period during which the plots have been under full treatment.

TABLE 6.—HARTSBURG FIELD: BLACK SILT LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soybeans	Alfalfa
		5 crops	8 crops	7 crops	4 crops	2 crops	8 crops ¹
1	O.....	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M.....	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML.....	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP.....	38.2	56.0	57.3	(2.62)	(1.92)	(4.04)
5	O.....	33.3	46.8	43.8	.74 ²	25.8	(3.19)
6	R.....	34.0	58.2	55.6	1.22 ²	26.8	(3.60)
7	RL.....	32.0	63.7	54.9	1.32 ²	28.4	(3.28)
8	RLP.....	36.4	61.1	59.0	1.41 ²	26.1	(3.83)
9	RLPK.....	35.2	59.5	57.2	1.42 ²	26.4	(4.01)
10	O.....	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

¹No residues except on last two crops.

²In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues, however, there appears to be on the whole little advantage from the use of limestone.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type shows about 1,600 pounds of phosphorus per acre in the surface stratum, which is a relatively high content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime were applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 7 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoian glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 8.



Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 4.—CORN ON RALEIGH FIELD IN 1920

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests with litmus paper and hydrochloric acid, as explained under the discussion of limestone on page 32 of the Appendix.

TABLE 7.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0.....	23.9	32.3	15.8	.50
2	L.....	21.3	26.8	13.2	.30
3	LR.....	21.3	29.9	20.6	.33
4	LP.....	30.7	43.6	36.7	1.08
5	LK.....	23.7	27.8	19.2	.57
6	LRP.....	33.8	43.3	33.3	.57
7	LRK.....	24.3	26.9	20.8	.59
8	LPK.....	25.1	38.2	30.9	1.26
9	LRPK.....	38.3	42.6	28.0	.33
10	RPK.....	38.4	44.7	30.2	.67

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

TABLE 8.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops	Soybeans 4 crops
1	0.....	17.3	10.4	5.8	(.26)	(.65)
2	M.....	29.7	13.0	7.7	(.31)	(.81)
3	ML.....	40.9	20.0	21.0	(1.08)	(1.08)
4	MLP.....	41.2	20.3	21.5	(1.32)	(1.24)
5	0.....	17.3	10.3	7.0	(.00)	.01 ²
6	R.....	20.1	12.8	8.4	(.00)	.01 ²
7	RL.....	34.9	21.5	18.8	(1.60) ¹	.10 ²
8	RLP.....	36.5	22.7	21.2	(1.61) ¹	.09 ²
9	RLPK.....	41.9	23.6	22.4	(1.79) ¹	.12 ²
10	0.....	19.6	11.6	6.5	(1.06)	(.57)

¹One crop only (1920).²Average of two crops.

YELLOW SILT LOAM

A soil fertility experiment field on yellow silt loam is located at Elizabethtown, in the southern end of the state, but this field has not been in operation long enough to furnish results that can be used.

However, some experiments in pot culture have been conducted with soil of this type, the results of which furnish useful data in indicating the proper management of this kind of soil.

In one experiment a large quantity of typical worn hill soil was collected from two different places. Each lot of soil was thoroly mixed and put into ten four-gallon jars. Wheat was planted in one series and oats in the other. Ground limestone was added to all the jars except the first and last in each set, those two being retained as control, or check pots. The elements nitrogen, phosphorus, and potassium were added singly and in combination, as shown in Table 9.

As an average, the yield produced where nitrogen was applied, was about eight times as large as that secured without the addition of nitrogen.

But there is no need whatever to purchase nitrogen, for the air contains an inexhaustible supply of it which, under suitable conditions, the farmer can draw upon, not only without cost, but with profit in the getting. Clover, alfalfa, sweet clover, cowpeas, and soybeans are worth raising not only because of their value as crops but because of their power, when properly inoculated with nitrogen-fixing bacteria, to secure nitrogen from the atmosphere.

In order to secure further information concerning the best practice in building up the nitrogen content, another experiment with pot cultures was conducted for several years with the same kind of worn hill soil as that used for wheat in the former experiment. The results are reported in Table 10.

To three pots (Nos. 3, 6, and 9) nitrogen was applied, in commercial form, at an expense amounting to more than the total value of the crops produced. In three other pots (Nos. 2, 11, and 12) a crop of cowpeas was grown during the late summer and fall and turned under before the wheat or oats were planted. Pots 1 and 8 served for important comparisons. After the second cover crop of cowpeas had been turned under, the yield from Pot 2 exceeded that from Pot 3; and in the subsequent years the green manure from legumes produced, as an average, somewhat better results than the commercial nitrogen. This experiment confirms the previous one in showing the very great need for nitrogen for the improvement of this type of soil—and it also shows that nitrogen need not be purchased but that it can be obtained from the air by growing legume crops and plowing them under as green manure. Of course the soil can be very markedly improved by feeding the legume crops to live stock and returning the resulting farm manure to the land, if legumes are grown frequently enough and if the farm manure produced is sufficiently abundant and is saved and applied with care.

As a rule, it is not advisable to try to enrich this type of soil in phosphorus, for with erosion, which is sure to occur to some extent, the phosphorus supply will be renewed from the subsoil.

Probably the best legumes for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter, sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value

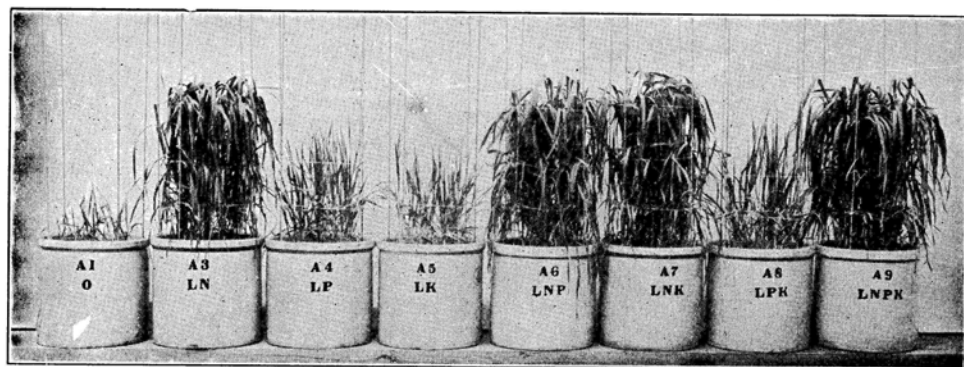


FIG. 5.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
The need of nitrogen (N) on this type of soil is clearly demonstrated.

TABLE 9.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN
HILL LAND
Grams per pot

Pot No.	Soil treatment applied	Wheat	Oats
1	None.....	3	5
2	Limestone.....	4	4
3	Limestone, nitrogen.....	26	45
4	Limestone, phosphorus.....	3	6
5	Limestone, potassium.....	3	5
6	Limestone, nitrogen, phosphorus.....	34	38
7	Limestone, nitrogen, potassium.....	33	46
8	Limestone, phosphorus, potassium.....	2	5
9	Limestone, nitrogen, phosphorus, potassium.....	34	38
10	None.....	3	5
Average yield with nitrogen.....		32	42
Average yield without nitrogen.....		3	5
Average gain for nitrogen.....		29	37

in increasing the organic matter and in preventing washing. Worthless slopes, where the land has been ruined by washing, may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa started well requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 5 tons) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to give the alfalfa a quick start in order that it may grow rapidly and thus protect the soil from washing.

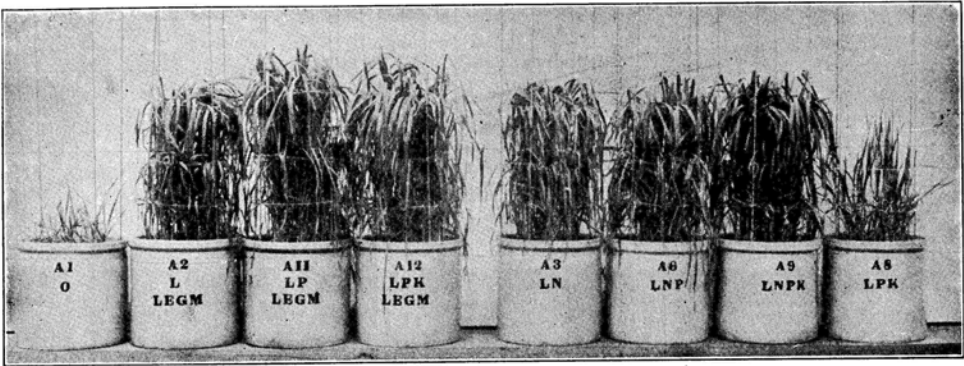


FIG. 6.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
In the pots at the right, nitrogen is applied in commercial form. In the pots at the left, nitrogen is secured from the air thru the growing of legumes.

TABLE 10.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN MANURE CROPS
Grams per pot

Pot No.	Soil treatment applied	1903 Wheat	1904 Wheat	1905 Wheat	1906 Wheat	1907 Oats
1	None.....	5	4	4	4	6
2	Limestone, legume.....	10	17	26	19	37
11	Limestone, legume, phosphorus.....	14	19	20	18	27
12	Limestone, legume, phosphorus, potassium.....	16	20	21	19	30
3	Limestone, nitrogen.....	17	14	15	9	28
6	Limestone, nitrogen, phosphorus.....	26	20	18	18	30
9	Limestone, nitrogen, phosphorus, potassium.....	31	34	21	20	26
8	Limestone, phosphorus, potassium.....	3	3	5	3	7

DUNE SAND

In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

The following table indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 41.

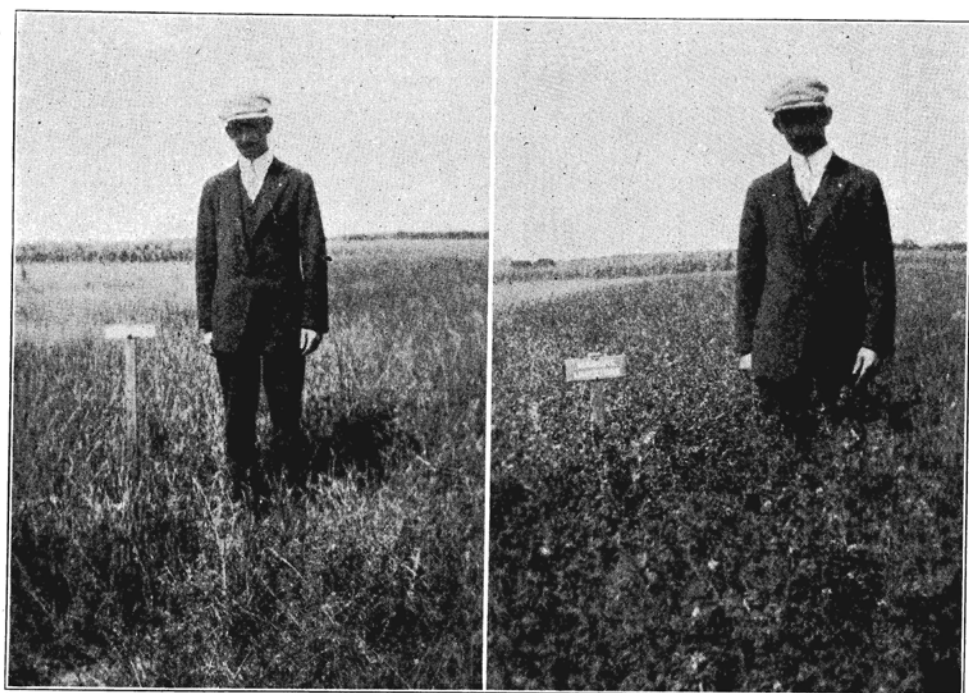
The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

TABLE 11.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soybeans ¹ 5 crops	Wheat 6 crops	Sweet clover 4 crops	Rye 4 crops	Alfalfa 3 crops
1	0.....	14.3	(.89)	6.4	0	12.1	(.11)
2	M.....	18.9	(1.01)	8.1	0	13.3	(.13)
3	ML.....	23.4	(1.27)	9.7	(1.20)	20.1	(1.88)
4	MLP.....	22.2	(1.20)	10.1	(1.26)	19.5	(2.03)
5	0.....	14.4	3.5	7.4	2 crops (0) 2 crops 0	13.7	(.14)
6	R.....	16.2	3.5	8.1	(0) 0	14.1	(.12)
7	RL.....	29.3	6.6	9.1	(1.47) 2.53	23.2	(2.05)
8	RLP.....	29.3	6.4	10.4	(1.39) 2.20	24.2	(1.90)
9	RLPK.....	32.7	6.0	9.4	(1.53) 2.84	23.7	(1.86)
10	0.....	11.4	(.60)	6.4	(0)	10.6	(.06)

¹ In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.



Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 7.—ALFALFA ON OQUAWKA FIELD IN 1918

Altho the results show an increase of 3.4 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and this is insufficient data upon which to base conclusions. The other crops all show negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

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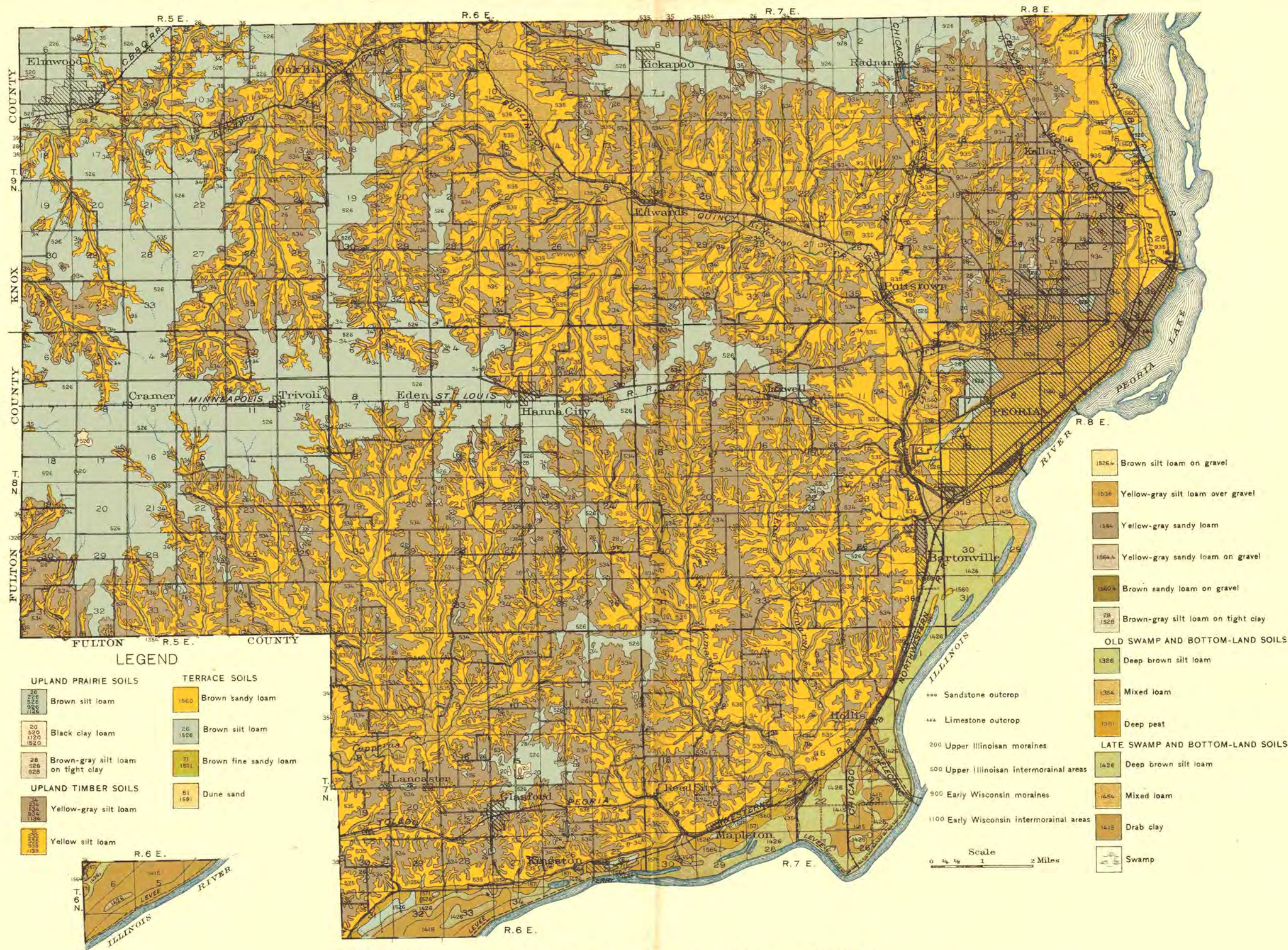
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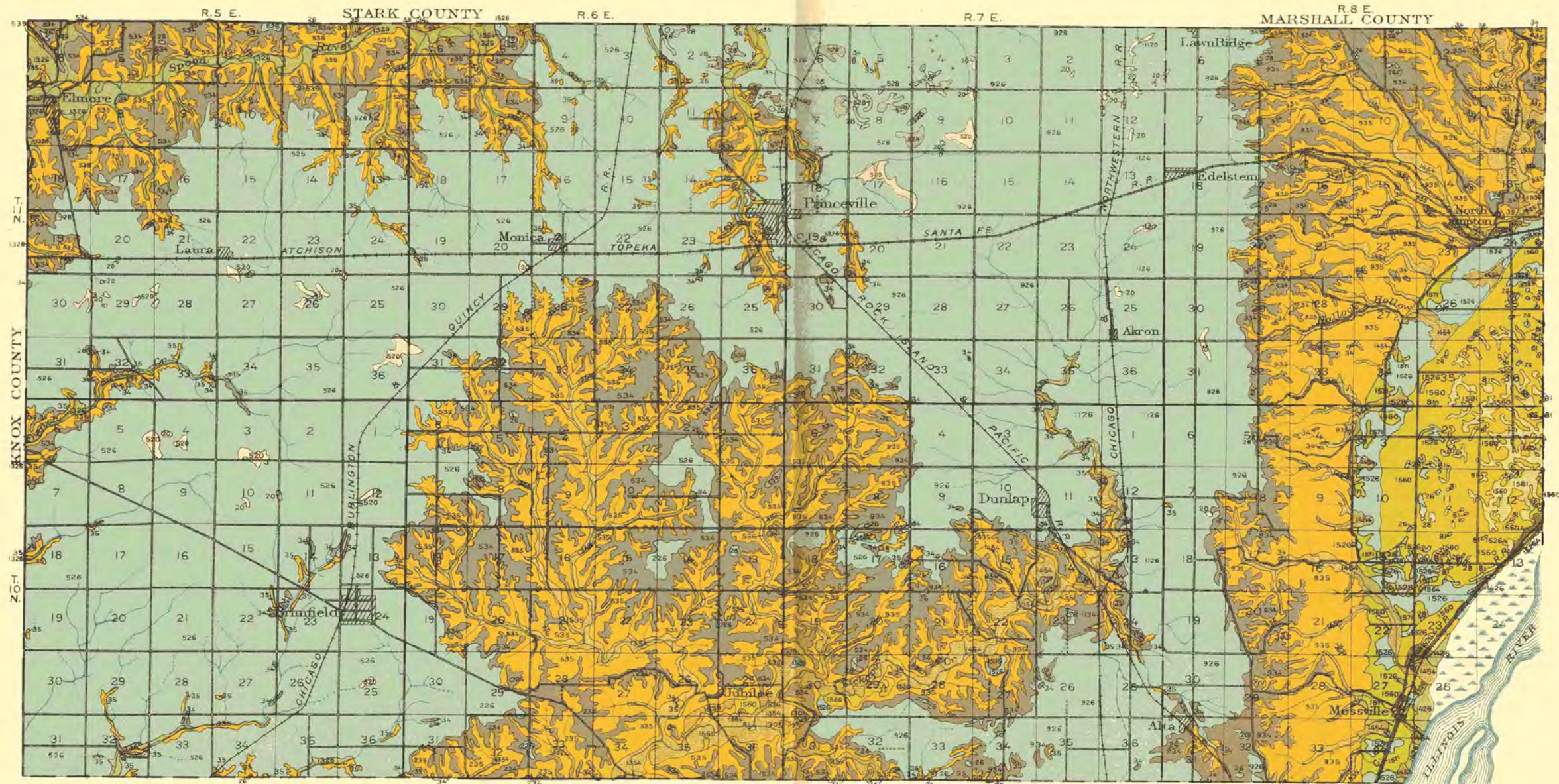
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SOIL SURVEY MAP OF PEORIA COUNTY
UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION



LEGEND

UPLAND PRAIRIE SOILS		OLD SWAMP AND BOTTOM-LAND SOILS	
26 1571	Brown silt loam	1326	Deep brown silt loam
20 1520 1520	Black clay loam	1384	Mixed loam
28 1528 1528	Brown-gray silt loam on tight clay	1304	Deep peat
UPLAND TIMBER SOILS		LATE SWAMP AND BOTTOM LAND SOILS	
31 1531 1531	Yellow-gray silt loam	1426	Deep brown silt loam
35 1535 1535	Yellow silt loam	1452	Mixed loam
TERRACE SOILS		1415	Drab clay
1560	Brown sandy loam	1415	Swamp
26 1526	Brown silt loam		
71 1571	Brown fine sandy loam		
81 1581	Dune sand		
1526.4	Brown silt loam on gravel		
1536	Yellow-gray silt loam over gravel		
1544	Yellow-gray sandy loam		
1544.4	Yellow-gray sandy loam on gravel		
1560.4	Brown sandy loam on gravel		
26 1528	Brown-gray silt loam on tight clay		

- *** Sandstone outcrop
- *** Limestone outcrop
- 200 Upper Illinoian moraines
- 500 Upper Illinoian intermorainal areas
- 900 Early Wisconsin moraines
- 1100 Early Wisconsin intermorainal areas

Scale
0 1 2 Miles



SOIL SURVEY MAP OF PEORIA COUNTY UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION